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GB 2225543 A GB 1436403 A GB 1436402 A
GB 1272683 A EP 0246036 A1 US 4878930 A

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(54) Vacuum cleaner filter

(57) A filter in a vacuum cleaner comprises a pleated sheet of semi-rigid sintered polyethylene 14. The filter may be generally flat but is preferably tubular, with end caps, one of which has a outlet opening. A rotating arm 31 carries strikers 32, which strike the inner folds 17 or the inner ends of radial supports inside each pleat (Fig. 8), to shake dust from the outside of the filter. The filter may be made from one pleated sheet or separate sheets forming each side of each pleat, welded together along the fold lines. The sheet(s) may have dimples to prevent pleats from flattening in use. Fold lines may be heat set. The filter can be cleaned in a domestic washing machine.

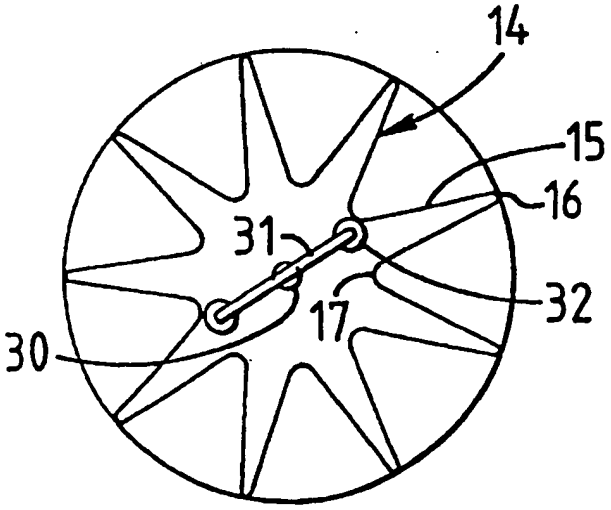

FIG. 3

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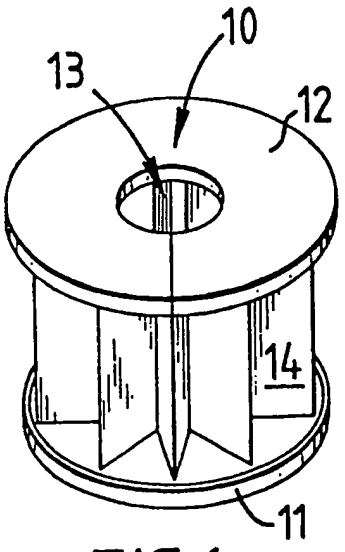

FIG. 1

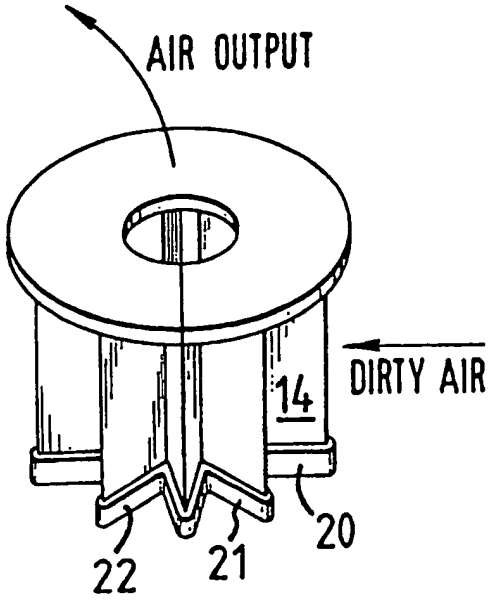

FIG. 2

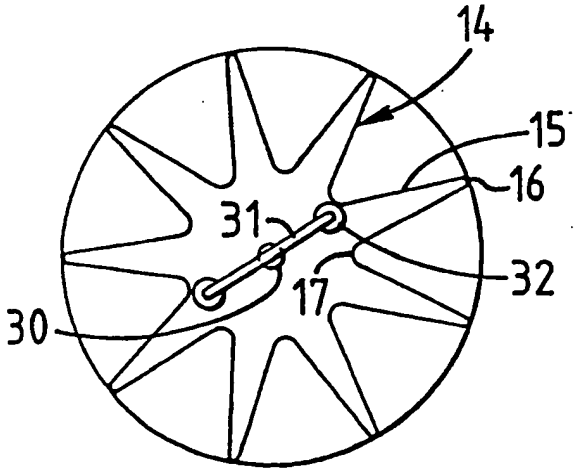

FIG. 3

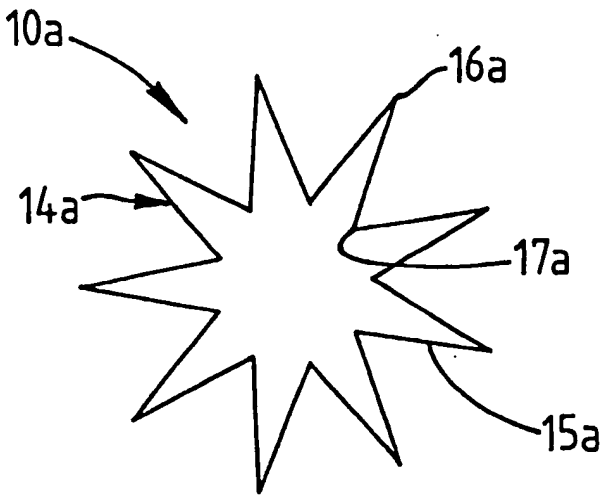

FIG.4

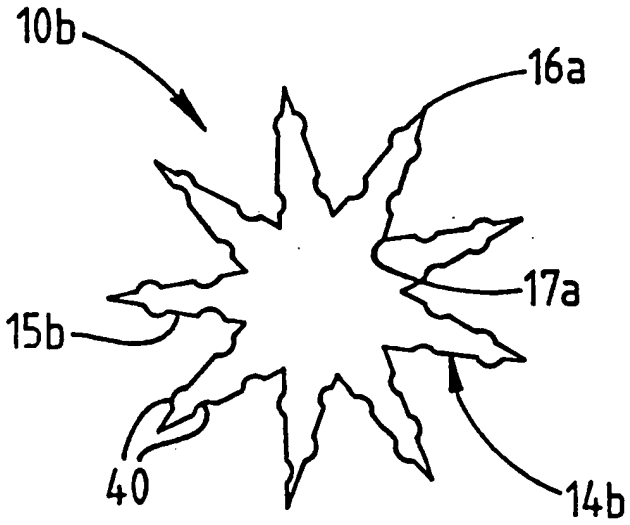

FIG.5

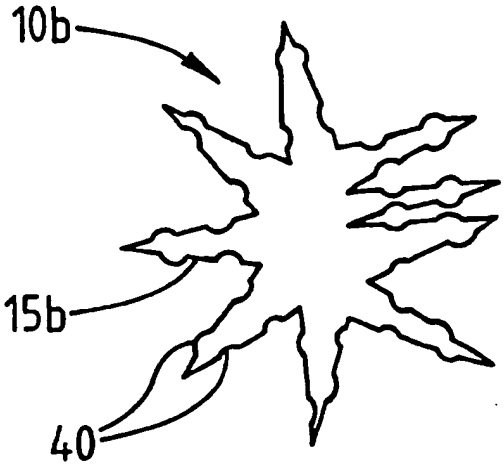

FIG.6

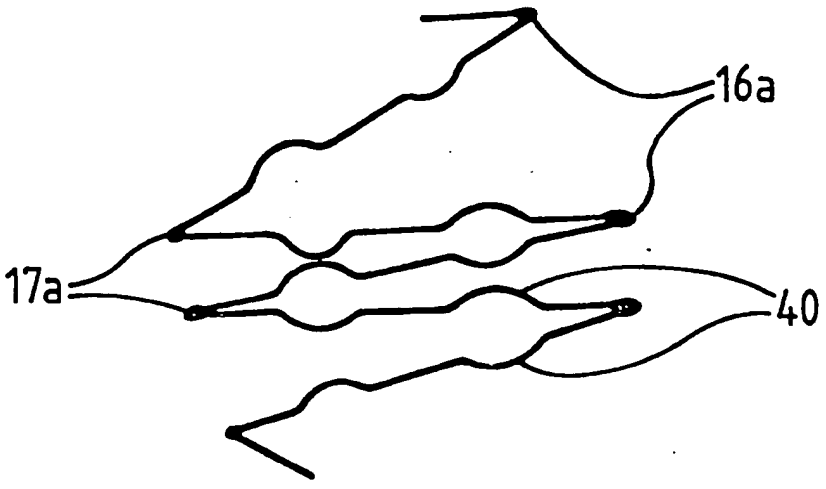

FIG.7

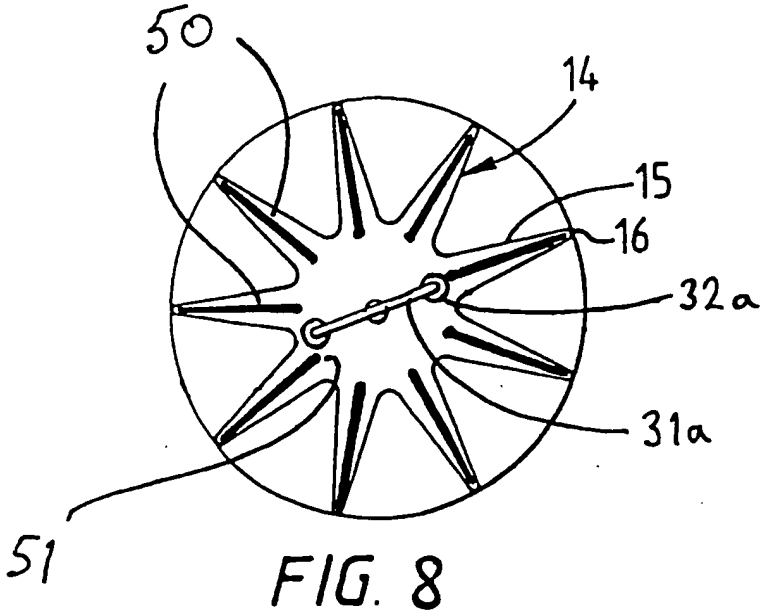

FIG. 8

FILTER

DESCRIPTION

The present invention relates to filters and has particular reference to filters for gas or air filtration and in particular to filters for use in vacuum cleaning apparatus.

Air filtration systems are well known and are much used in motor cars and vacuum cleaning equipment. In vacuum cleaning equipment, however, present filtration systems are very much a compromise. The efficiency of a vacuum cleaner is directly related to the volumetric air flow per unit time through a given nozzle. The higher the air flow, the more efficient the cleaning operation. The design of vacuum cleaning equipment is, therefore, based on obtaining the maximum air flow through the machine commensurate with filtering out the greatest amount of material. Large vacuum cleaners with powerful motor systems have extensive filtration facilities which include cyclone filters and multiple layer filters which permit removal of substantially all the particulate material in an air or gas stream. These machines, however, are bulky and are typically employed in a commercial or industrial location; it is desirable to scale such machines down in size for use in a domestic environment. In a domestic or contract cleaning

environment, vacuum cleaning equipment needs to be reasonably compact and have effective filtering and at the same time to permit as high a volumetric air flow per unit time through the machine as possible commensurate with adequate filtering. If the efficiency of the filtration arrangement is increased, the effect of this is usually to produce a reduction in volumetric air flow per unit time.

Typical vacuum cleaning equipment at the present time uses a combination of air filters backed up if necessary with disposable paper filters usually in the form of bags. Fabric filters used in such vacuum cleaning equipment are usually of relatively coarse pore size and permit the filtering of the dirt and debris for collection by the machine, but permit the passage of very fine dust which is then redischarged into the atmosphere. The use of a paper bag in combination with such a filter results in a much more efficient filtration initially, but as the fine particles become trapped within interstices of the paper substrate constituting the filter, the pores of the paper filtration membrane become progressively blocked and the air volumetric efficiency is reduced and along with it, the efficiency of operation of the machine overall. Furthermore, as the paper bag fills, the effective area of filter available for filtration is gradually reduced, thereby further reducing

the volumetric air throughput of the machine. This necessitates changing the paper bag at frequent intervals, usually before the bag is completely full of debris and dirt. Reusable filters in domestic and contract cleaning vacuum machines are relatively bulky and their use in domestic machines has not been possible due to the limitations of size.

The man skilled in the art is aware of the fact further that the greater the surface area of the filter, the more efficient can be

a) the filtration, and

b) the volumetric air efficiency

of the machine concerned when considered over a given period of time.

Air filtration equipment for use with relatively clean air and gas streams frequently uses pleated paper filters. These are suitable for use in vacuum cleaning machines and typical of such filtration units is that described in European Patent Specification No. 169330. Such filters suffer from the disadvantage, however, that they are of complex construction and not significantly reusable. They can be treated in service to prolong their life, but when dealing with fine particles of almost colloidal dimension within an air stream, such a filter is rapidly blinded and the partial cleaning

described in European Patent Specification No. 169330 will not dislodge such particles. As a result the volumetric efficiency of such a filter reduces.

Our prior European Patent Specification No. 0202066 provides for a plurality of filter elements disposed on a mounting plate. The filter elements have a smooth low friction surface such that when subject to negative pressure, the dirt and dust collects on the surfaces when the negative pressure is switched off, the dust formed within the filter element falls into a dust receptacle. These devices are, however, more suitable for large vacuum cleaning machines.

In one aspect of the present invention, therefore, there is provided a filter for a gas or air stream which filter comprises a filter membrane and support means therefor, characterised in that the filter membrane is formed with a plurality of folds or pleats, extending in at least one direction and in that said membrane is a semi-rigid sheet comprising a porous plastics material, the arrangement being such that the support means locates and maintains said membrane within the gas stream in service and permits cleaning of the membrane for reuse.

In another aspect of the invention, the combination of folds or pleats serves to impart a stiffness to the

membrane so that in combination with the support means, the membrane is maintained in filtering relationship with the gas stream in service. This means that an asymmetric air stream impinging upon the filter element in accordance with the invention is acceptable without the need to make special arrangements for supporting the filter membrane in a given area.

In a typical aspect of the present invention, the pleated membrane may be in the form of a cartridge of generally cylindrical configuration having a plurality of longitudinally extending folds which define a number of substantially radial pleats. A former at one end serves to close said one end and is configured in a generally star-shaped arrangement to accommodate the edge of the cylindrical pleated structure of the sheet material. The other end may be provided with a generally annular closure member, the central bore of which is large enough to provide for an air flow into or out of the filter element.

In a further aspect of the invention, the folds or pleats in the membrane are radiused to allow folding and pleating of the membrane without substantial breakdown of the filter efficiency in the region of each pleat.

In another aspect of the present invention the filter may

comprise a planar filter having support means around the edge thereof with pleats or folds extending in at least one direction transverse the plane of the support. The support may be peripheral and may include gasket means for engaging with the air passageway in which the filter is to be located. The rigidity of the filter in situ in a machine will permit brushing by a circular brush or by reverse air flow or vibration or alternative means.

The filter membrane may according to a further aspect of the present invention be formed of a semi-rigid sintered polyethylene material, preferably a medium or high density sintered polyethylene material and may be in a form of a sheet solus or in the form of a laminate with a further supporting structure such, for example, as a fabric carrier.

In a further aspect of the present invention, the filter membrane may comprise one or more discrete sheets or laminates, which one or more sheets or laminates are joined one to another, each at an apex of the fold or pleat. The individual sheets or laminates may be joined, for example, by welding or by using a suitable adhesive. The filter membrane may, for example, comprise a single folded or pleated sheet having a first end and a second end, which sheet has been formed into a continuous membrane by joining the first and second ends one with

the other.

The thickness of the layer constituting the filter membrane can be adjusted as can the porosity to provide the desired degree of porosity for the particular filter commensurate with the volumetric efficiency of the machine with which it is to be employed. Porous polyethylene in sheet form such as that commercially available under the trade name "VYON" has been found to be of particular value in this regard. Where a polyethylene membrane is employed, a further aspect of the invention provides that the folds or bends defining each pleat are heat set.

In another aspect of the present invention, the filter membrane may comprise substantially smooth surfaces and/or uneven surfaces. The sheet or sheets forming the membrane may further comprise one or more indentations or raised areas. One purpose contemplated for an indented membrane is to maintain an air flow through the filter should adjacent pleats become forced together one with another while the filter is in use. This may occur, for example, in the event of mechanical failure within the filter, or if debris particles having unusual dimensions and/or very high momentum strike the membrane wall.

In another aspect of the present invention the pleats and

folds may be in the form of a tessellated structure extending across a substantially planar filter. This imparts a high degree of rigidity. The shaping can be effected by, for example, vacuum moulding or simply by "pressing" at an elevated temperature well below the melting or sintering temperatures of polyethylene, to provide setting of shape, fold or bend.

In a further aspect of the present invention there is provided a shaker mechanism which can dislodge the build-up of dirt and debris on the dirty side of the filter in situ in a vacuum cleaning machine. The pleated material of the filter in accordance with the present invention may have sufficient rigidity to withstand mechanical forces encountered in use and is capable of being cleaned by brushing and vacuuming. The filter can also be removed from the vacuum cleaning machine and subjected to reverse air flow and vibration of the pleats, and may also be washed. The washing of filters accompanied by reverse air or water flow therethrough is the most effective and efficient way of cleaning a vacuum cleaner filter. In spite of the relatively high cost of manufacturing such a filter, such a filter can be constructed in a way to provide extremely effective dust and debris filtration without severe loss of performance and without the need for any form of primary filters such as, for example, disposable paper filter bags.

In a particular aspect of the present invention a filter unit in accordance with the present invention may be cleaned by simply placing it in a domestic washing machine.

The supports for the membrane may include or comprise a bonding medium which is capable of bonding to the membrane itself. The supports may include at least one end cap arranged to engage with the end edges of the pleated medium and to bond and/or seal with the same, thereby closing the end. Where an end cap is provided at each end, one of the end caps may have a central hole through which is attached a vacuum source so that dirty air is pulled through the pleats from the exterior to the interior of the filter. In an alternative embodiment, the air flow may be designed in the other way, where in this case, removal of the debris from within the filter unit is more difficult unless the whole thing is of a much more massive construction.

In accordance with a further aspect of the present invention, the pleats are spaced such that as debris builds up on the surface, bridging of the apices or outer ends of the pleating does not occur. In a further aspect of the invention to additionally overcome this problem of build-up, the outer surface should be of a low friction nature so that when the vacuum or negative

pressure applied across the vacuum cleaning surface is removed, the bulk of the debris collected thereby will readily fall away into a collecting receptacle provided for the purpose below.

Cleaning of the filter in service can be effected by vibration of the pleats. This may be conveniently achieved by striking the pleats on the clean air side by use of a rotary device which impacts with each pleat in turn. Alternatively, the filter may be adapted for rotation about the device which may remain static or rotate counter the direction of rotation of the filter.

In an alternative embodiment of the invention, an internal piece may be inserted between each pleat and a device arranged to strike these instead. Each internal piece may be in the form of a substantially rigid "finger", and may be located in the support means. The internal pieces serve to space apart adjacent surfaces of the membrane, and to agitate the filter membrane when struck, for example, by the rotary device.

In a particular aspect of the invention, there is provided a pleated filter in accordance therewith which is closed at both ends, one of the closed ends having an air exit orifice and the other being shaped to define the pleated structure.

In a more specific embodiment of the present invention there is provided a generally cylindrical filter element for filtering the gas flow, which filter comprises a filter membrane and a support therefor, said filter membrane having a plurality of longitudinally extending folds extending longitudinally of the cylindrical filter. The said folds may serve to define a plurality of pleats arranged in a generally star-shaped structure within the filter, the pleats being closed at the first end by a correspondingly star-shaped closure member which follows the contours of the pleats and is bonded thereto to close the end thereof and at the other end by an annular closure member defining a central air outlet through which air is evacuated from within the filter thereby drawing air through the membrane from the outside of the filter to effect the filtering operation.

A rotary device may, in service, be entered within the air exhaust outlet, rotation of which causes the device to strike the internal extremity of each inward pleat thereby vibrating the same to dislodge dirt and debris disposed on the external surface thereof. Alternatively, an internal piece may be located between each pleat, and the rotary device may be adapted for striking the internal pieces which pieces agitate the filter membrane.

Following is a description by way of example only and

with reference to the accompanying drawings of methods of carrying the invention into effect.

In the drawings:-

Figure 1 is a diagram of a cylindrical cartridge filter of the present invention for use in vacuum cleaning equipment.

Figure 2 is an alternative embodiment of the filter shown in Figure 1.

Figure 3 is a section through each of the filters of Figures 1 and 2 showing the operation and effect of an in-service cleaning device.

Figure 4 is a section through a different filter of the present invention to that shown in Figure 3.

Figure 5 is a section through another filter of the present invention.

Figure 6 is a section through the filter of Figure 5 showing adjacent pleats which has become forced together.

Figure 7 is a magnified view of part of the filter shown in Figure 6.

Figure 8 is an alternative embodiment of the filter shown in Figure 3.

Turning now to the device shown in Figure 1, the filter 10 is a generally cylindrical cartridge filter having a lower closed end gap 11 and an upper end cap 12 having a central opening 13 for the exhaust of air from the interior of the filter. The filter membrane is formed from a sheet of porous polyethylene material commercially available under the trade name "VYON" which is formed into a closed longitudinal conduit extending between end cap 11 and upper cap 12, the sheet being arranged in a plurality of, in this case 9, radially extending pleats or folds each defined by a longitudinally extending fold. Each fold 16, 17 is radiased to prevent cracking of the membrane and in this example has been heat set for added strength. Each pleat is substantially symmetrical about a radius of the cylinder and the included angle of a radius of symmetry of each pleat between adjacent pleats is approximately 45 to 60°. The ends of the pleated membrane are sealed with each of the end plates 11 and 12 by means of an adhesive.

In the embodiment of Figure 2 the closed end 20 is configured to have an identical configuration to that of the pleats. The end plate 20 is configured to have a

star shaped closure surface 21 and an upstanding portion 22 which is adapted to overlay an edge portion of the pleated membrane 14. The overlay 22 permits bonding between a face of each pleat and provides a much stronger support and location for each pleat in service. The structure at the other end closure cap 12 remains the same as for Figure 1.

Figure 3 is a section through each of the filters of Figures 1 and 2. The location of the membrane walls 15 of each pleat, the locus of the extremity 16 of each pleat and the base 17 of each pleat can clearly be discerned. The axis of the filter contains a rotatable rod 30 carrying an arm 31 rotatable therewith and at each end of arm 31 a spring loaded striker 32. Rotation of the rod 30 results in corresponding rotation of the arm 31 to bring each striker 32 into contact with the innermost extremity of the junction between adjacent pairs of pleats. This results in a shaking of the adjacent sidewalls of the two pleats with a result that any debris adhering thereto is removed therefrom. The structure of the pleated material is arranged with the low friction surface presented externally, that is on the outer surface of the membrane 14, thus aiding release of material adhering thereto.

Figure 4 is a section through the filter 10a in which the

membrane wall 15a is formed of a plurality of discrete sheets 14a. Each sheet is joined by welding to one adjacent sheet at extremity 16a and to another adjacent sheet at base 17a of each pleat. The filter membrane shown in Figure 4 is formed from eighteen individual sheets.

Figure 5 is a section through the filter 10b in which the membrane is formed of an indented wall 15b. The indented wall is formed of individual sheets 14b, each sheet having indentations or raised areas 40. Each sheet is joined with one sheet at extremity 16a and with another sheet at base 17a of each pleat.

Figure 6 is the section view through the filter 10b in which adjacent sheets have become forced together. The sheets, and an effect of the indentations, are shown in a magnified view in Figure 7 in which it will become apparent that adjacent indentations and raised areas serve to space adjacent sheets so as to allow an air flow through the membrane wall.

In the embodiment of Figure 8, an internal piece 50 is located between each pleat. Arm 31a is somewhat shorter in length than arm 31 shown in Figure 3. A striker 32a is positioned at each end of the arm 31a. The arm is caused to rotate so as to bring each striker 32a into

contact with the innermost extremity 51 of each piece. This results in agitation of the filter membrane by the internal piece; debris adhering to the membrane is removed therefrom.

The pleated structure in accordance with the present invention can be readily removed from a vacuum cleaner as a unitary whole and can be further cleaned or washed to remove dirt and debris therefrom. This maintains the filtering efficiency of the filter and enables the filter to be reused.

The filtering efficiency of such a filter can be much higher than with existing fabric filters and the volumetric air efficiency of the filter compared with its filtration performance is more effective over a period of time in a cycle of service than that of corresponding paper filters.

CLAIMS

1. A filter for a gas or air stream, which filter comprises a filter membrane and support means therefor, characterised in that the filter membrane is formed with a plurality of folds or pleats, extending in at least one direction and in that said membrane is a semi-rigid sheet comprising a porous plastics material, the arrangement being such that the support means locates and maintains said membrane within the gas stream in service and permits cleaning of the membrane for reuse.

2. A filter as claimed in claim 1, characterised in that the combination of folds or pleats serves to impart a stiffness to the membrane so that in combination with the support means, the membrane is maintained in filtering relationship with the gas stream in service.

3. A filter as claimed in claim 1 or claim 2, characterised in that the pleated membrane is in the form of a cartridge of generally cylindrical configuration having a plurality of longitudinally extending folds which extend between one end and another end and which define a number of substantially radial pleats.

4. A filter as claimed in claim 3, characterised in that a former at one end serves to close said one end and

is configured in a generally star-shaped arrangement.

5. A filter as claimed in claim 3 or claim 4, characterised in that the other end is provided with a generally annular closure member having a central bore adapted for providing an air flow into or out of the filter element.

6. A filter as claimed in any preceding claim, wherein the folds or pleats are radiused.

7. A filter as claimed in any preceding claim comprising a planar filter having support means around an edge thereof with pleats or folds extending in at least one direction transverse the plane of the support.

8. A filter as claimed in any preceding claim characterised in that the filter membrane is formed of a semi-rigid sintered polyethylene material in the form of a sheet or a laminate.

9. A filter as claimed in any preceding claim, characterised in that the filter membrane comprises one or more discrete sheets or laminates, which one or more sheets or laminates are joined one to another, each at an apex of at least one fold or pleat.

10. A filter as claimed in any preceding claim, characterised in that the filter membrane comprises a folded or pleated sheet or laminate having a first end and a second end, which sheet or laminate has been formed into a continuous membrane by joining the first and second ends one with the other.

11. A filter as claimed in any preceding claim characterised in that the folds or bends defining each pleat are heat set.

12. A filter as claimed in any preceding claim characterised in that the filter membrane comprises substantially smooth surfaces and/or uneven surfaces.

13. A filter as claimed in any preceding claim, characterised in that the membrane comprises one or more indentations or raised areas.

14. A filter as claimed in any preceding claim, characterised in that the pleats and folds define a

a dirty side of the filter in situ in a vacuum cleaning machine.

16. A filter as claimed in any preceding claim, characterised in that the filter is cleaned by placing in a domestic washing machine.

17. A filter as claimed in any preceding claim, characterised in that the support means for the membrane comprise a bonding medium which is capable of bonding to the membrane itself.

18. A filter as claimed in any preceding claim, characterised in that the support means include at least one end cap adapted for engaging with end edges of the pleated medium and for bonding and sealing with the same.

19. A filter as claimed in claim 18, characterised in that one end cap comprises a central hole adapted for receiving a vacuum source so that dirty air is pulled through the pleats from the exterior to the interior of the filter.

20. A filter as claimed in any preceding claim, characterised in that the pleats are spaced such that as debris builds up on an outer filtering surface, bridging

of the apices or outer ends of the pleating is substantially prevented.

21. A filter as claimed in claim 20 characterised in that the outer surface is of a low friction nature.

22. A filter as claimed in any preceding claim, characterised in that an internal piece is inserted between adjacent pleats and means are provided for striking said internal piece.

23. A filter as claimed in any of claims 3 to 22 which is closed at both ends, one of the closed ends having an air exit orifice and the other end being shaped to define the pleated structure.

24. A generally cylindrical filter element for filtering a gas flow, which filter comprises a filter membrane and a support therefor, said filter membrane having a plurality of longitudinally extending folds extending longitudinally of the cylindrical filter between a first end and a second end.

25. A filter as claimed in claim 24 characterised in that the folds serve to define a plurality of pleats arranged in a generally star-shaped structure within the filter, the pleats being closed at the first end by a

correspondingly star-shaped closure member adapted for following contours of the pleats and for bonding thereto to close the end thereof, and closed at the second end by an annular closure member defining a central air outlet through which air is evacuated from within the filter thereby drawing air through the membrane from the outside of the filter to effect a filtering operation.

26. A filter as claimed in claim 25 characterised in that a device adapted for rotation is entered within the air outlet, rotation of which causes the device to strike the internal extremity of each inward pleat thereby vibrating the same to dislodge dirt and debris disposed on an external surface thereof.

27. A filter as claimed in claim 25 characterised in that a device adapted for rotation is entered within the air outlet, and an internal piece is located between each pleat, the arrangement being such that rotation of the device causes the device to strike each internal piece thereby vibrating the same so as to cause said piece to agitate the filter membrane to dislodge dirt and debris disposed on an external surface thereof.

28. A filter substantially as hereinbefore described with reference to and as shown in Figure 1 or Figure 2, or Figure 3 or Figure 4, or Figures 5, 6 and 7, or Figure

8 of the accompanying drawings.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 -24- (The Search report)	Application number GB 9414956.4
Relevant Technical Fields (i) UK Cl (Ed.M) B1D (DDGA, DDQA) B1T (TDGA, TDQA, TNCB, TNRT) (ii) Int Cl (Ed.5) A47L 9/12; B01D (29/03, 29/33, 29/35, 46/14, 46/24, 46/52)	Search Examiner R T HAINES Date of completion of Search 14 SEPTEMBER 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii)	Documents considered relevant following a search in respect of Claims :- 1-28

Categories of documents

X:	Document indicating lack of novelty or of inventive step.	P:	Document published on or after the declared priority date but before the filing date of the present application.
Y:	Document indicating lack of inventive step if combined with one or more other documents of the same category.	E:	Patent document published on or after, but with priority date earlier than, the filing date of the present application.
A:	Document indicating technological background and/or state of the art.	&:	Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2225543 A	(ENVAIR LTD)	1,2,7,9,11
X	GB 1436403	(MITSUBISHI DENKI KK)	1,2,7,11,15 22
X	GB 1436402	(MITSUBISHI DENKI KK)	1-3,5,15 18-20,22-27
X	GB 1272683	(INDUSTRIAL FILTER CO)	1-3,5,8,10, 18-20,23,24
X	EP 0246036 A1	(JAPAN GORE-TEX INC) Figure 5	1-3,5,24
X	US 4878930	(MANNISO)	1-6,18,19,20 23-25

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